

A MULTIPLAYER HUMAN-IN-THE-LOOP AUTONOMOUS DRIVING SIMULATION FRAMEWORK WITH VIRTUAL REALITY TECHNOLOGY

Defu Cui

Yuzhong Shen

Department of Electrical and Computer Engineering

Old Dominion University

5115 Hampton Blvd

Norfolk, VA, USA

{dcui001, yshen}@odu.edu

ABSTRACT

Autonomous vehicles are believed to share the roads with human-driven vehicles and pedestrians as well as other road users in the near future. Simulation has become a crucial tool for development of autonomous driving. It is imperative to include human-in-the-loop in the autonomous driving simulation. Towards this goal, this paper proposes a multiplayer autonomous driving simulation framework to enable human-in-the-loop simulation for vehicle drivers, pedestrians, and spectators simultaneously engaging in the simulation with the assistance of virtual reality technology. The proposed multiplayer human-in-the-loop simulation framework is developed by leveraging the CARLA autonomous driving simulator, and the network multiplayer architecture and a client-server model in Unreal Engine. Virtual reality technology is utilized to provide users with immersive experience during simulation. This paper presents our in-progress work in building the multiplayer human-in-the-loop autonomous driving simulation framework.

Keywords: Human-in-the-Loop Simulation, Autonomous Driving, Virtual Reality.

1 INTRODUCTION

Simulation has been utilized for assessing the performance of autonomous vehicles (AVs), which provides more flexibility for testing AVs without posing any danger to the real-world environments. There are some AV simulators such as CARLA that is the state-of-the-art and widely used simulator (Dosovitskiy et al. 2017). Mixed traffic environments will exist that consist of human-driven vehicles, AVs, pedestrians, and other road users. Therefore, it is necessary to include human-in-the-loop simulation in testing AVs. Virtual Reality (VR) provides a cost-effective way to study traffic simulation. For instance, Hasan et al. developed a distributed microscopic traffic simulation framework in which VR technologies were utilized for multiple human-controlled vehicles and pedestrians (Hasan et al. 2021). Silvera et al. presented a VR driving simulator based on CARLA for behavioral and interaction research (Silvera, Biswas, and Admoni 2022). To the best of our knowledge, there are no AV simulation frameworks that incorporate VR technology and multiplayer human-in-the-loop simulation in the mixed traffic environments. Therefore, this research aims to develop a multiplayer human-in-the-loop simulation framework with VR technology to support vehicle drivers, pedestrians, and spectators simultaneously joining AV simulation.

2 PROPOSED SIMULATION FRAMEWORK AND METHODOLOGY

Figure 1 illustrates the proposed simulation system and framework, respectively. The simulation server is hosted on a computer. Multiple VR and non-VR clients connect to the host server that shares simulation state information with each connected client. The client can choose their role (vehicle driver, pedestrian, or spectator) in the simulation. The development of proposed simulation framework utilizes CARLA source code and network multiplayer architecture in Unreal Engine. CARLA provides powerful Python APIs and ROS bridges for connecting to ROS based AV stacks such as AutoWare and Apollo, which uses the Remote

Procedure Call (RPC) server and RPC clients for information exchanging during the AV simulation. Employed network multiplayer architecture in Unreal engine, a CARLA network server and clients are developed for human-in-the-loop simulation. Networking components and the replication system built into Unreal Engine are adopted for communication and data synchronization between the CARLA network server and its clients. Virtual reality technology is incorporated in the clients for users to immerse in virtual 3D traffic simulation environments. In addition, Meta Quest 2 are used as VR headsets of clients.

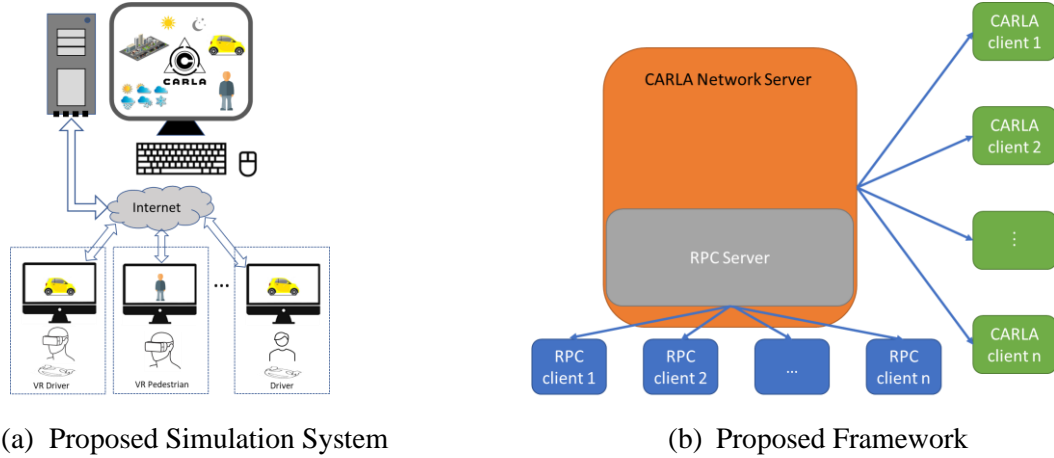


Figure 1: Proposed Simulation System and Framework.

3 RESULTS AND CONCLUSIONS

Figure 2 demonstrates the preliminary results. When configuring the simulation server, the user can set up the simulation map and the number of users joining the simulation. Before the user joins the simulation, each user can select simulation role as a spectator, a pedestrian, or a vehicle driver.

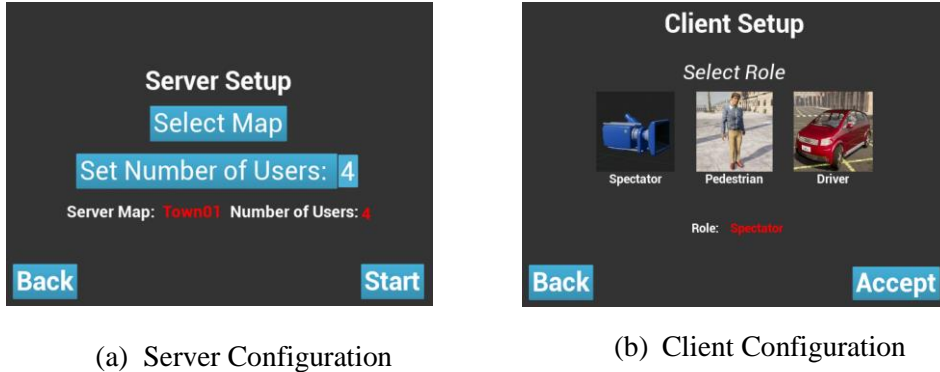


Figure 2: Preliminary Results: (a) Server Configuration Menu; (b) Client Configuration Menu.

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